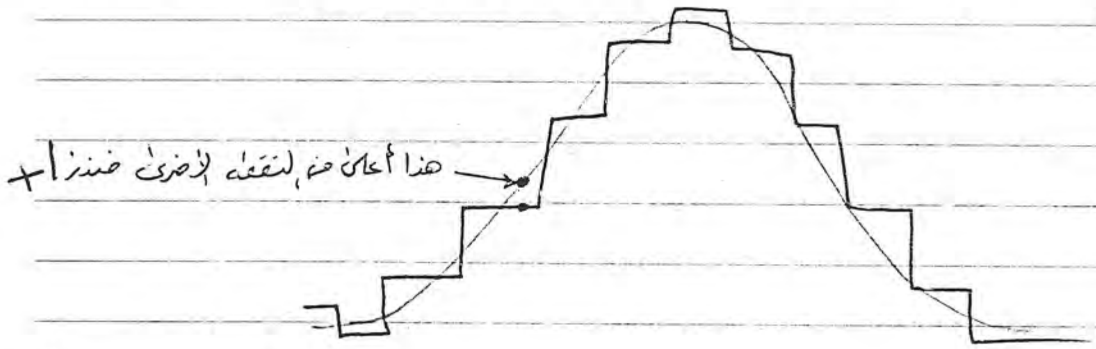
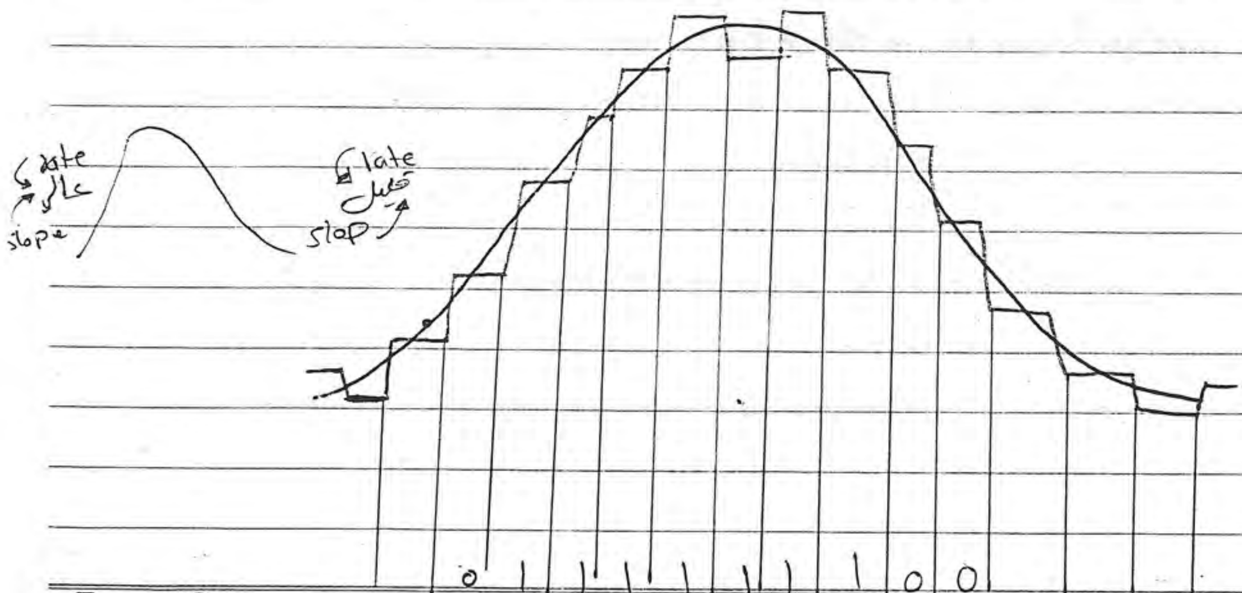
Delta Modulation:- The signalling rate and transmission Channel bandwidth are large in pcm, since it transmits all the bits which are used to code



Operation of Delta Modulation:-

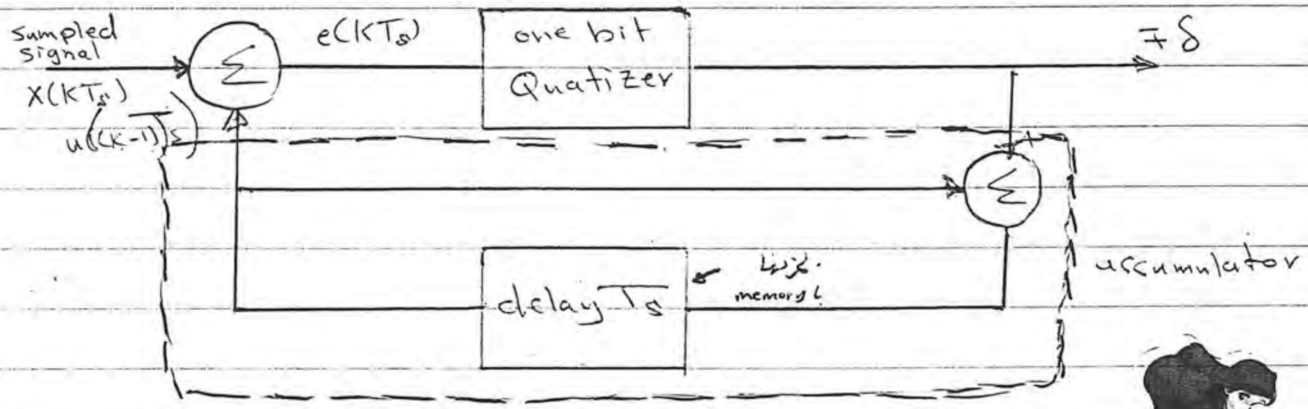
The present sample value is compared with the previous Sample value and the delta wheather The difference between the input signal x(t) and staircase approxmated signal is define by two levels $+\delta$ or $-\delta$ which are fixed step size. If the difference is positive $+\delta$ is sent, if the difference is negative $-\delta$ is sent



" Delta modulation "

DM transmitter :-

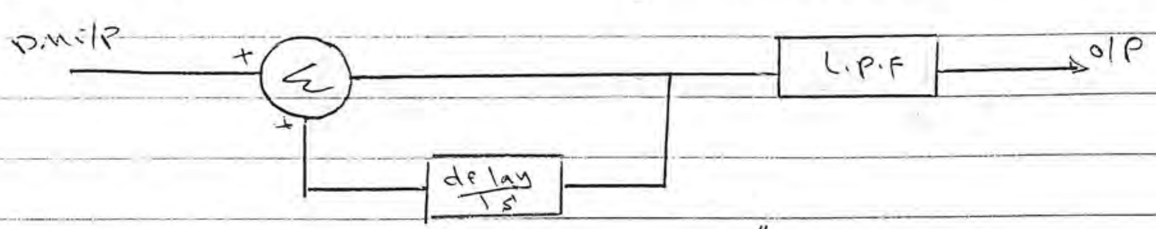
The pervious Sample approximation is restored by delaying one Sample period T_s. The error Signal $e(KT_s)$ is the staircase approximated Sabtracted from the sampled input signal $x(KT_s)$. Depending on the sign of $e(KT_s)$ one bit Quantizer produces an output step $+\delta$ or $-\delta$



" DM Transmitter "

DM receiver :-

The accumulator and alow pass filter is used. The accumulator generates the staircase approximated Signal output and is delayed by one Sample period (T_s). The delayed Sample is added if the input is "1" and Subtracted if the input is "0". The L.P.F has acuttoff frequency equal to the highst frequency in $x(t)$ to smoothen the staircase signal to reconstract $x(t)$.



" DM receiver "

التاريخ / /   الموضوع :

Advantages of DM :

1- channel bandwidth is small
2- The transmitter and receiver is very simple to implement, since there is No A/D converter.

Disadvantage of DM :
1- slope overload distortion ← بالطريقة التالية
2- granular noise (Hunting)

Derivation for the occurance of slope overload distortion :

$$x(t) = A_m \sin(2\pi f_m t)$$ في حالة sin

اما اذا كانت غيرها نشتق من جديد

The slop of $x(t)$ is maximum when the derivative of $x(t)$ with respect to (t) is Maximum

$$\text{Max slope} = \frac{\text{step size}}{T_s} = \frac{\delta}{T_s}$$
(مشتقة لل signal)

$$\text{Max}\left|\frac{dx(t)}{dt}\right| \geq \frac{\delta}{T_s}$$

$$\text{Max}\left|\frac{d}{dt}\left(A_m \sin(2\pi f_m t)\right)\right| \geq \frac{\delta}{T_s}$$

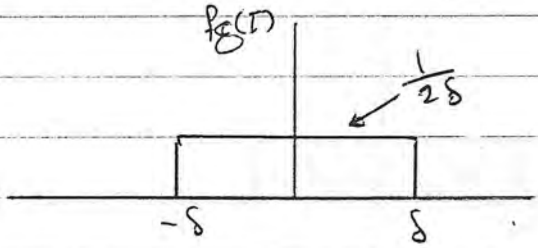
$$\text{Max}\left|A_m \left(2\pi f_m \cos(2\pi f_m t)\right)\right| \geq \frac{\delta}{T_s}$$

$$A_m 2\pi f_m > \frac{\delta}{T_s}$$

$$A_m > \frac{\delta}{2\pi f_m T_s}$$ for sinsiondle signal

Signal to noise ratio for DM modulation :

The Maximum Quantization error in DM is equal to δ. If the Quantization error is distributed uniformly $[\delta, -\delta]$



$$\text{Noise Power} = \frac{\overline{V^2_{noise}}}{R}$$

mean square error value $E[\varepsilon^2] = \overline{\varepsilon^2}$

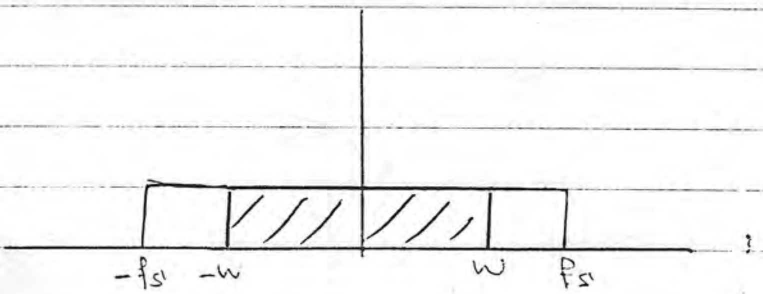
$$E[\varepsilon^2] = \int_{-\infty}^{\infty} \varepsilon^2 f_\varepsilon(\varepsilon)\, d\varepsilon$$

$$= \int_{-\delta}^{\delta} \varepsilon^2 \cdot \frac{1}{2\delta}\, d\varepsilon \Rightarrow \frac{1}{2\delta}\left[\frac{\varepsilon^3}{3}\right]_{-\delta}^{\delta}$$

$$= \frac{\delta^2}{3}$$

$$\text{noise power} = \frac{\delta^2}{3} \quad \text{if } R = 1$$

The noise Power is uniformly distributed over $-f_{s'}$ to $f_{s'}$ range.
AT the output there is a L.P.F reconstraction whose cuttoff frequency is w



$$\text{output noise power} = \frac{w}{f_{s'}} * \text{noise Power}$$

$$= \frac{w}{f_{s'}} * \frac{\delta^2}{3}$$

$$\text{output noise power} = \frac{w T_{s'} \delta^2}{3}$$ → at the receiver

$$\therefore \frac{S}{N} = \frac{3\,\overline{m(t)^2}}{w \delta^2 T_{s'}}$$ Assuming No slope over load distortion

if asignal is asinusoid signal

$$A_m = \frac{\delta}{2\pi f_m T_{s'}} \quad \text{——— (1)}$$

A_m : Peak of signal
f_m : frequency of signal
T_s : Sampling period

$P = \frac{V^2}{R}$ $R = 1$ $P = \frac{\delta^2}{8\pi^2 f_m^2 T_s^2}$

$P = V^2 \Rightarrow V = \frac{A_m}{\sqrt{2}}$ ——— ② Power Signal for Sinisoudel

Sub ① in ②

$$S/N = \frac{3}{8\pi^2 W f_m^2 T_s^3}$$ S/N power ratio in delta Modulation Post-filtering

Ex ll ADM System is designed to operate at 3 times the Nyquist rate for a signal with a 3KHZ bandwidth the quantizing step size is 250 mV.

① Determine the maximum amplitude of 1KHZ input sinsiodual for which the delta modulator does not shows slope overload.

② Determine the SNR for the signal of part ①

Sol:

① Nyquist rate $= 2 f_m$, $f_m = 1KHZ$

$f_s = 3 * 2 f_m$

$= 6 f_m$

$T_s = \frac{1}{f_s} = \frac{1}{6000}$

$$A_m \leq \frac{\delta}{2\pi f_m T_s}$$

$$\leq \frac{250 * 10^{-3}}{2\pi (1000)(\frac{1}{6000})}$$

Maximum amplitude is 238.7 mV

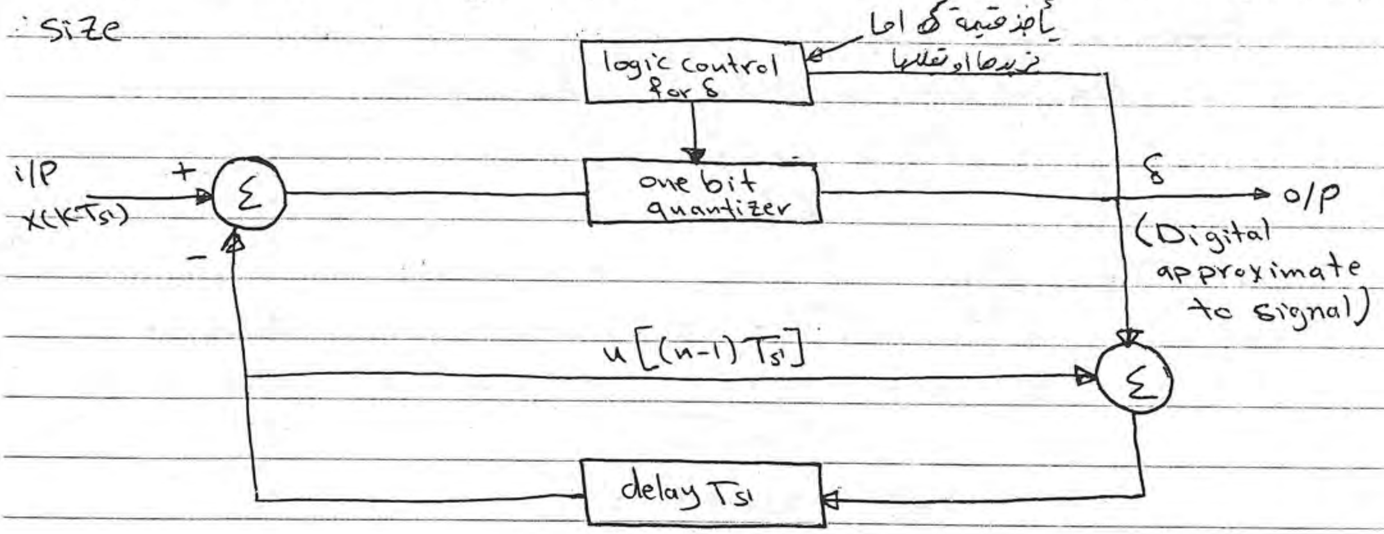
2) $$\frac{S}{N} = \frac{3}{8\pi^2 w f_m^2 T_{s1}^3}$$

$$= \frac{3}{8\pi^2 (3000)(1000)^2 \frac{1}{(6000)^2}}$$

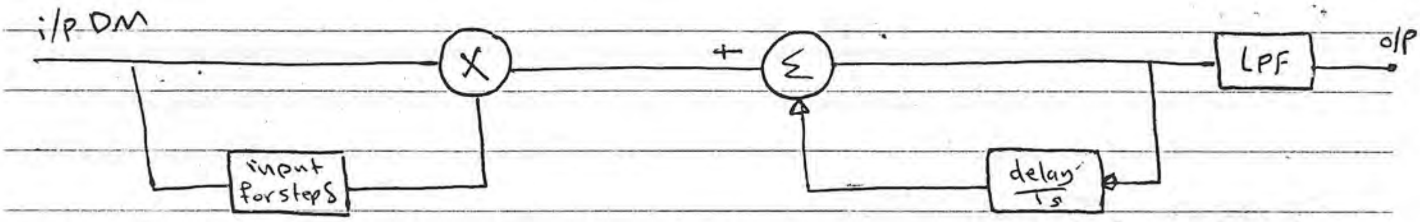
Adaptive Delta Modulation (ADM):

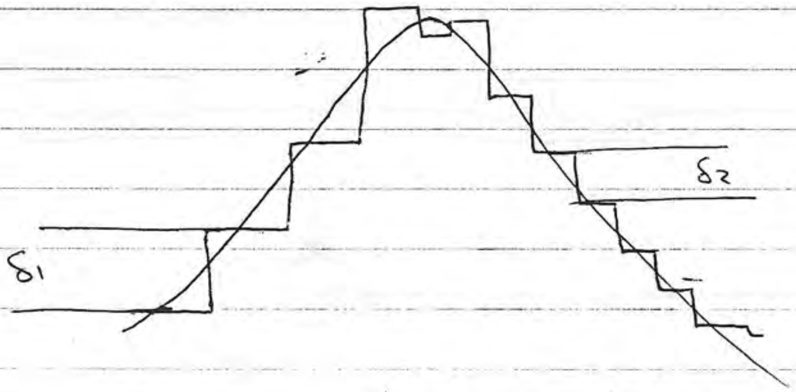
To overcome the Quantization due to slope overload and granular noise. The step size is made adaptive to the variations of the input signal x(t). The step size is reduced when the input is varying slowly. The method is called ADM

Transmitter: A logic control is added to control the step size



ADM Transmitter





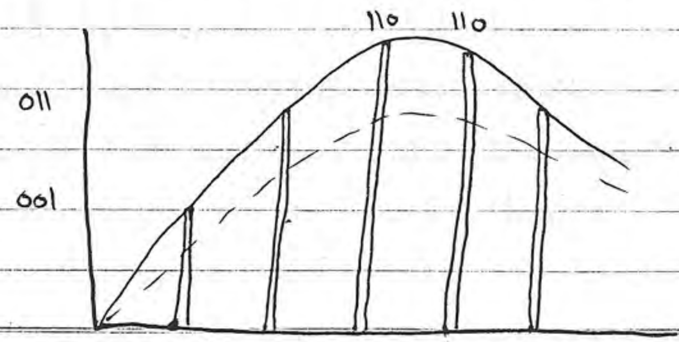
" ADM waveform "

Advantage of ADM

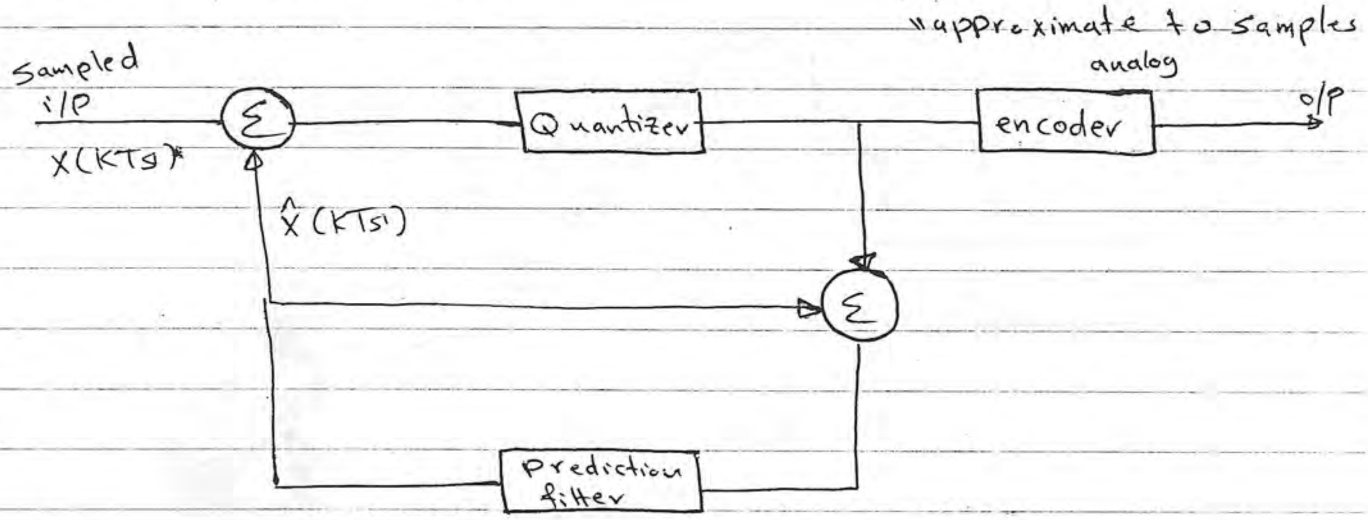
① S/N is better then DM
② The dynamic range of ADM is better than DM
③ requires less bandwidth then DM

Differential PCM (DPCM)

Samples are highly correlated with each other the present value from acertain value does not differ from the past Sample value



DPCM Transmitter

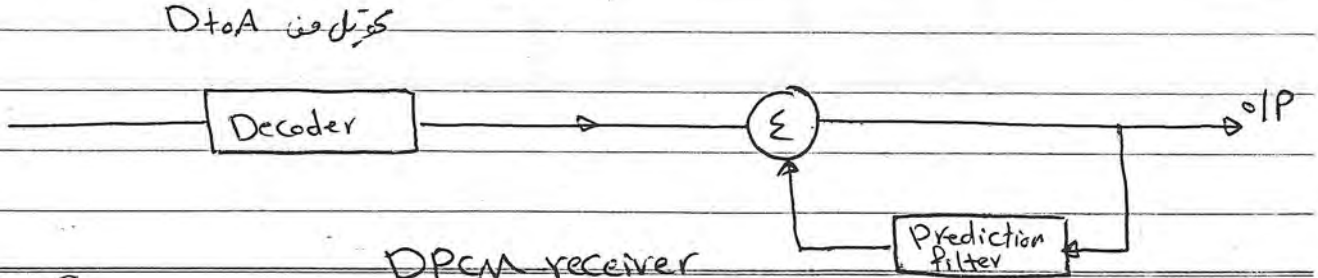


" DPCM transmitter "

The Predicted value is produced using prediction filter. The Quantized o/P signal and previous prediction is added and given as input to the prediction filter ($X_q(KT_s)$). This means that it makes the prediction more and more closer to the actual signal

Reconstruction of DPCM

The quantized error signal is reconstructed from incoming binary signal. The prediction filter output and Quantized error signals are summed up to give the Quantized version of the original signal



DPCM receiver